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Lambooij, Mattijs; Flache, Andreas; Siegers, Jacques; Lambooy, M.

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Mattijs Lambooij, Andreas Flache, and Jacques Siegers

ABSTRACT

In this paper, we examine whether and how the shadow of the future and risk aversion affect employee cooperation with the employer. We distinguish, formalize and test two conflicting arguments as used in the literature, which we denote the reward argument and the relation argument. Whereas the reward argument predicts that risk aversion affects cooperation in a negative way, the relation argument predicts a positive effect of risk aversion on cooperation. We show that both arguments are consistent with the view that a longer shadow of the future increases cooperation. Hypotheses are tested against survey data obtained from two samples of Dutch employees (N =109 and N = 213, respectively). The results suggest moderate support for the relation argument.

KEY WORDS • cooperation • organizations • risk aversion • shadow of the future

1. Introduction

It is a key challenge for work organizations to motivate their employees to invest effort at levels that go beyond what can be contractually specified or formally enforced. Long-term labor relations are an important governance instrument to achieve this goal (cf. Tsui et al. 1997; Baron and Kreps 1999). A long-term labor relation generates an ongoing exchange between employer and employee that gives both parties a 'shadow of the future' (Axelrod 1984) that provides the incentive to be cooperative in the present situation in order to secure the partner's continued cooperation in the future.

From the perspective of rational agents, however, cooperation in ongoing exchanges is not without problems. A central problem is the uncertainty as to whether future rewards for present investments will in

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fact be attained. For example, a firm may go bankrupt, or the employee may need to quit the job for personal reasons, before the reward is due. This risk is highlighted by theories that describe the labor relationship as a social exchange with delayed reciprocation. Integrating efficiency wage models (e.g. Akerlof 1982) and classical social exchange theories (e.g. Homans 1961; Blau 1964), Tsui et al. (1997) have proposed a 'mutual investment' model of the employer–employee relationship. Broadly, the mutual investment model predicts that employees will cooperate more if the employer invests more in 'career enhancement' for the employees, e.g. professional training or promotions. The underlying argument is that by making investments, the employer induces employees to invest in the labor relationship themselves, in order to balance the exchange. This is derived from the notion taken from social exchange theory that every relationship can be viewed as an exchange, which the actors in the relationship strive to balance in order to make sure that the relationship will continue. More specifically, the mutual investment model distinguishes between two layers of exchange. The first layer is the formal exchange of time for money, the second layer is constituted by an informal exchange that goes beyond the range of formal obligations. The mutual investment model predicts that when employers give their employees more than is specified in the contract, employees will be cooperative towards the organization, i.e. they respond with more effort than they are formally required to invest. This informal exchange can be found in the realm of career management in particular. When employers are willing to invest in careers of employees ('career enhancement'), employees are predicted to show more cooperative behaviors in return. A central mechanism that drives this prediction is that the (delayed) reward of a career move is much more impactful than a series of short-term rewards.

As Molm (1994) has pointed out, every exchange relationship bears risk, and so does the specific exchange between employer and employee as portrayed by the mutual investment model. By postponing career enhancement rewards by way of compensation for the cooperative behavior of employees, a time lag is introduced. With this time lag, uncertainty enters the decision-making process of employees. When an employee decides to invest extra effort to cooperate with the firms' interest, it may well be that between the moment of investment and the future reward some unexpected event occurs due to which the reward will not be obtained. This problem implies that the risk[1] attitude of employees will be an important condition for the success or failure of career enhancement. Most people generally prove to be risk averse, i.e. they prefer a certain outcome to a risky outcome with the same or – to a certain extent – even a higher expected value (see e.g. Herzog and Schlottmann 1990; Doucouliagos 1995; Donkers, Melenberg, and Van Soest 2001; Pindyck and Rubinfeld 2005). At the same time, there is evidence for considerable differences between people in the degree of risk aversion (e.g. Tversky and Kahneman 1992).

Risk aversion may explain why effects of career management are not always as straightforward as expected. For instance, Doucouliagos (1995) concludes that many workers, consumers, managers, and investors are, to a certain extent, risk averse and that this makes many people reluctant to start up or invest in new firms. Bloom and Milkovich (1998) argue that considering the entire compensation contract of the employee, studying risk may even be more important than studying incentives per se in order to understand effects of long-term rewards on the effort of employees. Furthermore, theoretical and experimental analyses of cooperation in repeated social dilemma games have provided evidence that the risk attitudes of individuals clearly affect their willingness to be cooperative (Raub and Snijders, 1997; Snijders and Raub 1998, Van Assen 1998). Repeated social dilemma games are, in turn, considered to be a model of the continued exchange in a long-term labor relation (cf. Baron and Kreps 1999). However, while previous research leaves little doubt that individual risk attitudes affect cooperation in long-term labor relations, the exact nature of these effects is far from evident.

There are broadly two lines of thought in the literature pertaining to the issue of how risk attitudes affect long-term labor relations. Baron and Kreps (1999) discuss a mechanism that we will call the 'reward' argument. From the point of view of the reward argument, risk aversion may affect an employee's willingness to cooperate, because the investment in cooperation with the employer made by an employee can be seen as a gamble on his part. The employee pays some effort now to obtain an uncertain reward, such as a promotion, in the future. If an actor is risk averse, he may prefer the certain outcome of no investment (and no reward) to the uncertain gamble between a payoff that is worse, investment without reward, and a payoff that is better, investment with reward, even if the certain outcome and the gamble have the same expected value. To explain, in utility theory risk aversion commonly refers to a preference that actors have for obtaining some outcome x for certain, above playing a gamble with equal expected value x that involves some probability p of earning a payoff higher than x, but also the risk of getting a lower payoff than x with probability $(1 - p)$. For a risk-averse player, if the expected outcome of the gamble equals x, the possibility of getting a higher payment than x in the lottery is not enough to offset the risk of ending up with less than x. As the popular proverb has it: 'A bird in the hand is worth two in the bush.' However, a risk-neutral actor would be indifferent as to the gamble and obtaining x for certain, because both outcomes have the same expected payoff.

For the reward argument, this suggests that the more risk averse employees are, the more weight they place upon the uncertainties that may disrupt the link between effort investment and future rewards. Risk-averse employees may be deterred in particular by the possibility that they (or the employer) will have to quit the working relationship unexpectedly, before the time has been reached when the reward will be granted. The suggestion that follows from this theoretical view is that delayed rewards need to be higher for risk-averse employees than for risk-neutral or risk-seeking employees. Or, when the reward and the delay are fixed, this suggests that employees are less willing to cooperate the more risk averse they are.

Raub and Snijders (1997; Snijders and Raub 1998) represent what we call the 'relation' argument. The implications of this argument with regard to effects of risk aversion are radically different from those of the 'reward' perspective. In the relation perspective, the labor relationship is characterized by ongoing reciprocity. That is: at any point in time, employer and employee alike will face the decision to cooperate or defect, but either party also knows that they will take these decisions vis-à-vis each other repeatedly in the future. The model of the labor relationship that corresponds to this view is that of an indefinitely repeated Prisoner's Dilemma (PD). It is a well-established fact that a sufficient shadow of the future may deter rational agents in this game from unilateral defection in the present, because they anticipate the undesirable consequence of losing the cooperation of others in the future. As a result, conditional cooperation is an individually rational strategy on this condition (cf. Friedman 1971; 1986; Axelrod 1984). Raub and Snijders have shown that, contrary to the reward argument, this model implies that risk aversion favors cooperation, or, conversely, that risk seeking undermines cooperation (Raub and Snijders 1997; Snijders and Raub 1998; Van Assen 1998). As the authors argue, in indefinitely repeated social dilemma games, risk aversion favors cooperation, because in 'a repeated game-framework using the logic of conditional cooperation … [t]he relevant problem for … a rational actor is whether he should try a unilateral exploitation of partners who cooperate conditionally. He has to weigh the short-term incentive for exploitation against the expected long-term costs of such a behavior. In a scenario of this type, risk aversion will favor own cooperation, while risk-seeking preferences will tend to favor defection' (Raub and Snijders 1997: 278–279). Here, the gamble involves risking losing the partner's cooperation in order to reap the benefits from exploitation of the partner. When this gamble yields the same expected value as continuation of mutual cooperation, a risk-averse player would prefer the latter option although the payoff of unilateral defection exceeds that of mutual cooperation.

The reward argument and the relation perspective are both consistent with Tsui et al.'s (1997) emphasis on the importance of long-term rewards for employee cooperation in ongoing labor relations. At the same time, the theories generate conflicting predictions on how individual risk aversion affects employee cooperation under the shadow of the future. This discrepancy sets the stage for our research. One could expect that for different types of organizations, using different types of incentive systems, risk aversion may lead to different behaviors, depending on whether the incentive structure corresponds more to the relation or to the reward model of an employer–employee relationship. One-shot long-term rewards such as becoming a professor, or granting the employee the status of partner in a law firm, may work differently from long-term rewards with more, but smaller steps, such as repeated training sessions or the gradual advancement on a promotion ladder in smaller steps.

In this paper, we use game theoretical elaboration of both theoretical arguments to generate corresponding testable hypotheses. We show how the predictions of each of the theories correspond to a different form of the incentive structure that the employee faces in the labor relationship, which in turn may be linked to different types of organizations to which each of the two theories applies. We then report a set of empirical studies in which these hypotheses were tested on questionnaire data that we obtained from two samples of Dutch employees (total N = 322). The game theoretical models and the corresponding hypotheses are presented in section 2. In section 3, we will describe the data, measurement, and the statistical methods used. Section 4 reports results of the empirical analysis. Results are discussed and conclusions are drawn in section 5.

2. Models and hypotheses

2.1 Modeling the reward argument: the delayed reward game

To express the intuitive reasoning of the reward argument in a more formalized way, we specify a delayed reward game that models the employer–employee relationship as it is seen from the point of view of the reward perspective. Baron and Kreps' (1999) reasoning mainly focuses on the perspective of the employee who faces the decision problem whether to invest in cooperation with the employer, at the risk of not obtaining the promised reward in the future. A full game theoretic analysis in the tradition of the principal-agent approach would model the features of the contract offered by the employer as the outcome of a rational choice of the employer anticipating the employee's rational behavior under the contract. To simplify our analysis, we assume in the following as given that the employer has offered a contract with the specified features and we focus only on the decision problem of the employee. We argue that this is sufficient to answer our question as to how risk aversion of the employee affects the employee's cooperation. Hence, for the delayed reward game, we assume that the employer has chosen rationally to enter into a binding contract with the employee in which it is specified that at some (fixed) time $t^* > 1$ in the future the employee will receive a reward R^* (e.g. promotion) if the employee has cooperated in all rounds up to and including t^*. If the employee did not cooperate in any of the rounds up to and including t^*, after t^* he receives no reward, i.e. a payoff of zero.

In every round, the employee's decision is to cooperate (C) or defect (D). Cooperation is costly, defection is not. We model the risk for the employee by a certain probability that if he cooperates, and thus will incur costs, there will nevertheless be no reward. More technically, we assume, as in Raub and Snijders, that after every round the game may continue with a fixed probability, α. This probability captures the shadow of the future in the sense that the higher α, the higher the probability that the reward will eventually be attained, if the employee has cooperated throughout the game. The first round at $t = 0$ will always be completed.

Adopting the method of Raub and Snijders (1997) for the delayed reward game, we model risk aversion in terms of a concave shape of the utility function over the stage game payoffs, $-c$ (costs of cooperation), 0 (defection or no reward), and R^* (reward). Figure 1 shows why a concave utility function over the stage game payoffs implements the assumption that risk-averse actors may prefer the certain payoff of defection (0) to a gamble with probability p of 'winning' the reward R^* and probability $(1 - p)$ of 'losing' and ending up with nothing but the invested costs for cooperation ($-c$). For sake of simplicity, we will assume throughout the remainder of the paper that risk preferences do not affect the utility that an actor derives from the worst-case outcome and the best-case outcome of the stage game. That is, in the delayed reward game $U(-c)$ and $U(R^*)$

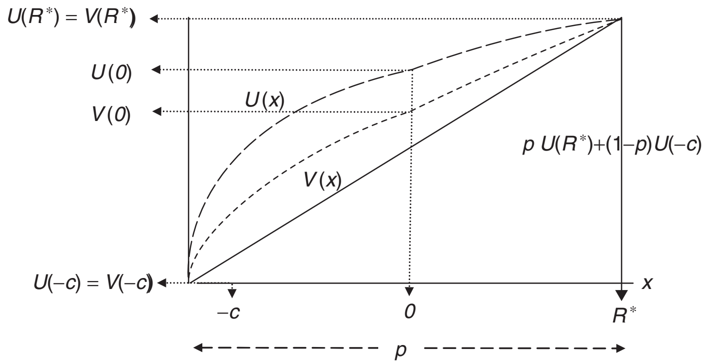

Figure 1. Concave utility functions implementing risk averse preferences in the range of possible stage game payoffs of the delayed-reward game

are not affected by an actor's risk preference, and $U(-c) < U(0) < U(R^*)$. The straight line connecting the payoff–utility pairs $(-c, U(-c))$ and $(R^*, U(R^*))$ in Figure 1 represents the expected payoff of a lottery in which the actor wins the worst-case payoff $-c$ with probability $(1-p)$, and the best-case payoff R^* with probability p. The higher the probability of winning, the closer the expected utility $u_L(\mathrm{p}) = (1-p)U(-c)+pU(R^*)$ is to the highest utility $U(R^*)$, and the smaller the probability of winning, the closer the expected utility is to $U(-c)$. Figure 1 shows two concave[2] utility functions U and V. Both functions implement risk aversion in the sense that whichever lottery p is chosen, the utility of getting the corresponding expected payoff for certain, $U((1-p)(-c)+pR^*)$, exceeds the expected utility of playing the lottery, $u_L(\mathrm{p}) = (1-p)U(-c)+pU(R^*)$. This implies that in particular a lottery q that has the same expected payoff as defection (0) yields a lower utility for a risk averse actor than defection itself. Alternatively, for a risk averse actor the probability p of getting the reward R^* must sufficiently exceed q to make this lottery more attractive than the option of defection.

In the following, we will derive for the delayed reward game the condition under which it is individually rational for employees to cooperate in all rounds. Subsequently, we will analyze how this condition changes when risk aversion is varied. As a first step, we obtain the expected utility of perpetual cooperation, u_C. This utility is the sum of two components. Its first element is the expected utility of obtaining the reward at time t^*, $p_R U(R^*)$, where p_R is the probability that the round t^* of the game will be reached. A player who chooses perpetual cooperation also expects to obtain the utility of investing the cost of cooperation, $U(-c)$, for the expected number of rounds l_c that the game will continue before it ends, either at t^*, or at some earlier point in time. Accordingly, we obtain u_C as given by equation (1).

$$u_c = p_R U(R^*) + l_c U(-c). \tag{1}$$

Given full cooperation, the probability that the reward is attained, p_R, equals the probability that the game continues after every iteration until round t^*, or

$$p_R = \alpha^{t^*} \tag{2}$$

The expected number of rounds for which the investment of full cooperation with the corresponding utility of $U(-c)$ is made, l_c, is obtained as

$$l_c = \frac{1-\alpha^{(t^*+1)}}{1-\alpha} \tag{3}$$

The proof is given in the appendix. The condition under which the employee chooses to cooperate in all rounds of the game is that $u_C > u_D$, where u_D denotes the best possible payoff that an employee can obtain when deviating from perpetual cooperation. This payoff can never be higher than in the case where the employee defects immediately from the first round on. The employee will then obtain the stage game utility of defection, $U(0)$, times the expected duration of the game, l_c. In addition, the employee will receive once more after round t^* a payoff of zero with utility $U(0)$, but only with the probability α^{t^*} that this round of the game is reached. Hence, $u_D = l_c U(0) + \alpha^{t^*} U(0)$. With this, we find after some rearrangement that the condition for the rationality of perpetual cooperation $u_C > u_D$, is equivalent to the condition given in (4).

$$\frac{\alpha^{t^*}}{l_c} > \frac{U(0) - U(-c)}{U(R^*) - U(0)} \tag{4}$$

The proof is given in the appendix. Further analysis of this result shows that this condition become less restrictive when α increases and more restrictive when t^* increases (for proof see appendix). In other words, the higher the probability that organization membership continues and the earlier the reward is due, the less restrictive are the conditions under which a rational employee cooperates in all rounds of this game. For the sake of convenience, let us interpret the difference between the left-hand-side (l.h.s.) and the right-hand-side (r.h.s.) of inequality (4) as the attractiveness of cooperation for the employee. Formally, the attractiveness of perpetual cooperation in the delayed reward game is given by

$$p_c = \frac{\alpha^{t^*}}{l_c} - \frac{U(0) - U(-c)}{U(R^*) - U(0)}\ .$$

To obtain hypotheses about actual behavior, we take the attractiveness of cooperation as an indicator of the likelihood that an employee cooperates. We assume that this likelihood is zero when condition (4) is not satisfied, but otherwise it strictly increases in the attractiveness of cooperation.[3] With this interpretation, we can reformulate our result in terms of a relationship between two continuous aggregate level variables. This yields the first hypothesis of our study (see formal derivation in the appendix).

Hypothesis 1. Employees will cooperate more with their employers if the shadow of the future is longer.

2.2 The relation model: the indefinitely repeated PD

In the following, we will show that hypothesis 1 is not only consistent with the reward argument but with the relation argument as well. As was done in earlier studies, we will describe the labor relationship from the point of view of the relation model as an indefinitely repeated PD game with stage game payoffs for the employee of T, R, P, and S, where T corresponds to unilateral defection (don't work but get a reward), R to mutual cooperation (work and get reward), P to mutual defection (employee does not work and employer does not pay the reward), and, finally, S to unilateral cooperation (employee works but employer does not live up to his promise to pay the reward). As in the reward model, risk aversion is modeled in terms of a concave utility function over the stage game payoffs, with utilities of $U(T) > U(R) > U(P) > U(S)$. Again, we model the shadow of the future with the assumption that the game may continue after every iteration with probability α. The well-known condition for the individual rationality of mutual perpetual cooperation in this game (see, e.g., Raub and Snijders 1997, who take this from Friedman 1971; 1986) then is:

$$\alpha > \alpha^* = \frac{U(T) - U(R)}{U(T) - U(P)} \tag{5}$$

where U(x) represents the utility that an actor derives from obtaining the payoff x in the stage game. The condition for cooperation given in (5) is obtained from the Nash-equilibrium condition for the individual rationality of mutual cooperation based on so-called trigger strategies (Friedman 1971; 1986). Like Axelrod's Tit-for-Tat, a trigger strategy starts with cooperation, but unlike it, the trigger strategy imposes perpetual punishment after any defection by the opponent. The advantage of analyzing trigger strategy equilibriums is that the rationality of cooperation based on trigger strategies is a necessary condition for the rationality of any form of cooperation based on reciprocity. If the punishment imposed by a trigger strategy is not sufficient to deter defection, no punishment can be severe enough (cf. Raub and Snijders 1997: 269). Clearly, condition (5) shows that perpetual cooperation is individually rational if the shadow of the future (α) is sufficiently long, but cooperation is not rational if α is too small. This is in line with our hypothesis 1, if again we adopt the interpretation that the difference between the l.h.s. and r.h.s. of the inequality, $\alpha - \alpha^*$ is an indicator of the attractiveness of cooperation and that the probability of cooperation strictly increases in attractiveness, but is zero for negative attractiveness. It should be noted though that condition (5) makes perpetual cooperation possible, but not inevitable. According to the well-known 'Folk theorem' of the theory of repeated games, 'if the players are sufficiently patient then any feasible, individually rational payoffs can be enforced by an equilibrium' (Fudenberg and Tirole 1991: 51) in an indefinitely repeated PD game. However, as argued above, the cooperative equilibrium we address here is of particular interest, because it allows assessing the conditions under which mutual and perpetual cooperation based on reciprocity can be individually rational at all.

2.3 Risk aversion and employee cooperation under the reward model

The delayed reward game highlights that long-term rewards imply a time lag between behavior and rewards. With this time lag, uncertainty enters the decision-making process. To derive implications from this model for the effects of risk aversion on cooperation, we introduce into the analysis of the conditions for cooperation the effects of risk aversion on the utilities of the stage game payoffs. This requires that we can compare different utility functions with each other with regard to the degree of risk aversion imposed by the utility function. Various measures have been proposed for this purpose, most prominently the Arrow–Pratt measure of absolute risk aversion (e.g. Pratt 1964). However, for our purposes, a simpler approach suffices. In the delayed reward game, the most important substantive property of risk aversion is that the employee prefers obtaining with certainty the 'interior payoff,' zero, to a gamble involving the two 'exterior payoffs', $-c$ and R^*. Correspondingly, in the repeated PD game risk aversion affects how actors evaluate a lottery that involves the three payoffs that shape condition (5), P and T as the exterior payoffs and R as the interior payoff. Thus, the more that, for a given utility function U, the utility of obtaining an interior payoff with certainty exceeds the utility of the gamble with the same expected value that involves the two exterior payoffs, the more risk aversion this utility function imposes, given our simplification that risk aversion does not affect the utility derived from the worst and the best stage game outcomes in conditions (4) and (5), respectively. This implies the following definition.

Definition 1

Consider two concave utility functions U and V defined on the range of payoffs [P..T] for the repeated PD game, or $[-c \,..\, R^*]$ *for the delayed reward game. Let* $U(P) = V(P)$ *and* $U(T) = V(T)$ *for the repeated PD game, and* $U(-c) = V(-c)$ *and* $U(R^*) = V(R^*)$ *for the delayed reward game. Then, the risk aversion of U is higher than the risk aversion of V if for any payoff x in the corresponding interval,* $U(x) > V(x)$.

This definition implies that for any gamble involving the two exterior payoffs, the higher the risk aversion of a utility function, the more the utility of obtaining with certainty the expected value of the gamble exceeds the expected utility of the gamble. Figure 1 illustrates definition 1 for the delayed reward game. The risk aversion of utility function U in this figure is higher than the risk aversion of utility function V, because for any possible payoff between the best and the worst stage game outcome, the corresponding utility of U is higher than the corresponding utility of V. This implies that if this payoff represents the expected value of some lottery involving these two stage game outcomes, the utility gain of obtaining the expected value with certainty rather than playing the lottery is higher for function U than for function V.

Definition 1 straightforwardly implies that higher risk aversion affects the restrictiveness of the condition for cooperation in the delayed reward game. The higher the risk aversion of a utility function U, ceteris paribus, the larger the term on the r.h.s. of inequality (4), which represents the difference between the utility obtained from defection and the utility derived from unilateral cooperation, $U(0) - U(-c)$, divided by the difference between the utility obtained from getting the reward and the utility of a zero payoff, $U(R^*) - U(0)$. At the same time, the term on the l.h.s. of condition (4) is not affected by risk aversion of U. This implies that the higher the risk aversion of a utility function, the smaller is the set of values of

α and t^* for which condition (4) is satisfied, or the lower the attractiveness of cooperation, all other things being equal (for proof, see appendix). We have thus shown that higher risk aversion makes the conditions for cooperation more restrictive from the point of view of the reward model. Again using the interpretation that the likelihood of cooperation increases in the attractiveness of cooperation, we obtain the following hypothesis.

Hypothesis 2a. The more risk averse employees are, the less they will cooperate.

2.4 Risk aversion and employee cooperation under the relation model

Inspection of condition (5) shows why the relation model generates a different implication for the effects of risk aversion than the reward model. Following definition 1, higher risk aversion implies that – ceteris paribus – the utility of the second best payoff, R, increases. Given our assumption that the utilities of the best and worst outcomes represented in (5), $U(T)$, and $U(P)$ are kept constant across different levels of risk aversion, it is immediately apparent that higher risk aversion decreases the threshold α^* in (5). This in turn renders the conditions for cooperation less restrictive as risk aversion increases (cf. Raub and Snijders, 1997, for similar results). The corresponding rival hypothesis of hypothesis 2a is given by hypothesis 2b.

Hypothesis 2b. The more risk averse employees are, the more they will cooperate.

2.5 Shadow of future, risk aversion, and employee cooperation

We argue that the two different models not only generate different implications for the effects of risk aversion, but they also make conflicting predictions for the interaction between the shadow of the future and employees' risk attitudes. The view of the reward model emphasizes that the risk of not receiving the future reward increases if an employee faces a longer duration of the employment relationship before the reward is due. The reward argument highlights that the larger the shadow of the future is, the larger would be the loss that an employee incurs in terms of foregone future benefits if he distorts the exchange relationship too early by unilateral defection. Thus, when we take the effects of risk aversion and of the shadow of the future into account simultaneously, we obtain different predictions, depending on whether the relation – or the reward argument is applied.

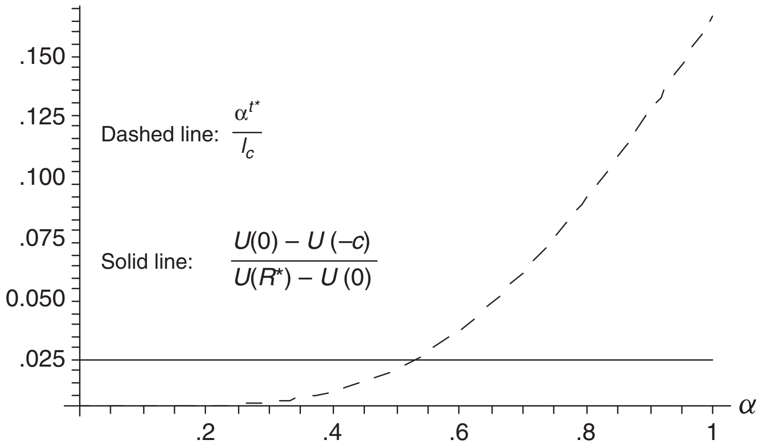

Figure 2. Effect of shadow of the future (α) on condition for perpetual cooperation in delayed reward game. $U(R^*) = 100$, $U(0) = 0$, $U(-c) = -2$, $t^* = 5$

More formally, within both models the strength of the effect of the shadow of the future, α, can be seen as the increase in the attractiveness of cooperation that obtains if α increases from its theoretical lower bound, zero, to its theoretical maximum of one. Figure 2 illustrates this for the example of the delayed reward game for the scenario of $U(R^*) = 100$, $U(0) = 0$, $U(-c) = -2$ and $t^* = 5$.

Figure 2 shows how an increase in the shadow of the future affects the condition for cooperation derived from the delayed reward game. The condition for cooperation given by (4) is satisfied as soon as α exceeds a value of about 0.53. At this point, the attractiveness of perpetual cooperation becomes positive. That is, the dashed line exceeds the solid line in Figure 2. The figure also shows that the distance between the two lines increases when the shadow of the future, α, increases. According to our probabilistic interpretation of the condition for cooperation (see note 3), this implies that the longer the shadow of the future, the higher the likelihood for employee cooperation. In the example given, the highest level of probability is obtained at $\alpha = 1$, where the attractiveness of perpetual cooperation approaches 0.1467. This value also indicates the strength of the effect of the shadow of the future, α, because it shapes the magnitude of increase between the probability of cooperation at $\alpha = 0$, where we assumed the probability to be zero, and the probability at $\alpha = 1$.

Figure 2 illustrates how, according to the reward model, higher risk aversion reduces the effect of the shadow of the future. For a given shadow of the future α, higher risk aversion increases, ceteris paribus, the term $\frac{U(0)-U(-c)}{U(R^*)-U(0)}$ on the r.h.s. of inequality (4), but it does not affect the term on the l.h.s., $\frac{\alpha^{t^*}}{l_c}$. As a consequence, the maximal attractiveness of cooperation that can be attained at a high shadow of the future (i.e. at $\alpha = 1$) decreases with risk aversion, which implies that the possible increase of the probability of cooperation that can be brought about by an increase of the shadow of the future, likewise decreases. More analytically, it follows from equation (1) that for every feasible set of stage game payoffs for the delayed reward game, the attractiveness of cooperation is negative if α is zero, which implies that the probability of cooperation is zero under this condition. In this case, the reward will never be attained, but the investment must be made for one round, resulting in an expected payoff $u_C = U(-c)$ for cooperation that is guaranteed to fall below $u_D = U(0)$. Mathematically, this also follows from condition (4). At $\alpha = 0$, the l.h.s. of (4) evaluates to 0, which by definition falls below the term on the r.h.s. That is, the attractiveness of cooperation is negative at $\alpha = 0$ and evaluates to $-\frac{U(0)-U(-c)}{U(R^*)-U(0)}$ (for proof, see appendix). We also know the attractiveness of cooperation if $\alpha = 1$. The limiting value of the attractiveness of cooperation if α approaches 1 is $\frac{1}{(t^*+1)} - \frac{U(0)-U(-c)}{U(R^*)-U(0)}$ (for proof, see appendix). According to the reward model, the strength of the effect of the shadow of the future, str_α, is obtained as the difference between the attractiveness of cooperation if $\alpha = 1$ and the attractiveness of cooperation if $\alpha = 0$, or technically

$$str_\alpha = \begin{cases} \frac{1}{(t^*+1)} - \frac{U(0)-U(-c)}{U(R^*)-U(0)}, & \text{if } \frac{1}{(t^*+1)} - \frac{U(0)-U(-c)}{U(R^*)-U(0)} > 0 \\ 0, & \text{otherwise.} \end{cases} \tag{6}$$

Equation (6) allows deriving the effect of risk aversion on the strength of the effect of the shadow of the future. Following our definition of the degree of risk aversion of a utility function, the higher the risk aversion (ceteris paribus), the larger is $U(0)$. Inspection of equation (6) shows that higher $U(0)$ decreases the effect of the shadow of the future on cooperation that is predicted by the delayed reward model. This also follows from the proof (see appendix) for the effect of risk aversion on the attractiveness of cooperation in the delayed reward game. The corresponding hypothesis reads:

Hypothesis 3a. The more risk averse an employee, the smaller the positive effect of the shadow of the future on cooperation.

Again, the relation argument suggests a different implication. From that view, risk-averse employees are particularly afraid to distort an ongoing exchange relationship with their employer. The darker the shadow of the future, i.e. the longer the employee expects the ongoing exchange to last if both sides continue to cooperate, the more substantial the loss that the employee may incur in terms of foregone future benefits would be. As a consequence, risk-averse employees are particularly motivated to avoid this loss. Technically, the increase in α of the probability of cooperation is higher for risk-averse agents than for risk-seeking agents. This follows from the condition of cooperation for the indefinitely repeated PD, given by (5), in combination with our probabilistic interpretation of the attractiveness of cooperation given by the difference between the l.h.s. and the r.h.s. of this condition $\alpha - \alpha^*$. At $\alpha=0$, the probability of cooperation is zero because (5) is never satisfied, at $\alpha=1$ it increases in $1-\alpha^*$. The term $1-\alpha^*$, in turn, increases in risk aversion because, as shown above, α^* decreases in risk aversion. Correspondingly, the rival hypothesis for hypothesis 3a reads:

Hypothesis 3b. The more risk averse an employee, the greater the positive effect of the shadow of the future on cooperation.

3. Method

3.1 Data collection

For the analyses we used two subsamples of data that were collected in the spring and summer of 2002: one in which risk aversion was measured in a general way using a lottery question and one in which risk aversion was measured in terms of job security.

The data used for this study were part of a research program called ‘Solidarity at Work’, which was conducted in the Netherlands between 2000 and 2005 by the Universities of Utrecht and Groningen, funded by the Netherlands’ Organization for Scientific Research (NWO). The program had the aim to answer questions on different forms of solidarity and cooperation in labor organizations. Besides questions on different forms of cooperative behaviors, structural aspects such as contract form and career measures were included, but also questions on informal aspects such as social networks. In this program, three different research strategies were used: (1) structured interviews with experts, (2) a written survey among employees and (3) vignette experiments. Fifteen organizations participated in the written survey and the overall response rate was 52%. The response rate at the university departments was lowest with 24% and at the printing company it was highest with 74%.

Because of the length of the questionnaire, many organizations demanded that it was shortened before they would cooperate. Therefore, the participating researchers constructed a modular structure in the questionnaire, so that sections of questions could be deleted and the questionnaire could be made shorter. This limited the range of organizations in which these parts could be included for a lot of the parts of the questionnaire. The sample for the analyses with the lottery question consists of data gathered in two organizations: a university department (n = 53), and a printing company (n = 56). The sample for the analyses with the job-security question consists of three organizations: a university department (n = 59), a healthcare organization (n = 91) and a printing company (n = 63). This means that the first subsample consists of 109 respondents and the second subsample of 213 respondents.

3.2 Description of measurements

In the empirical analyses, the supervisor was considered to be the employer's representative. Employee cooperation was thus measured in terms of cooperation with the supervisor. The dependent variable 'employee cooperation with the employer' was constructed using the following five items as suggested by Lindenberg (1998) and as used by other researchers (e.g. Koster, Sanders, and Van Emmerik 2003; Koster 2005; Koster and Sanders 2006):

- I will help my supervisor to finish the work.
- I am willing to help my supervisor when things have gone wrong for which nobody can be held responsible.
- I will apologize to my supervisor when I have made a mistake.
- I will try to share the pleasant and less pleasant tasks evenly amongst my supervisor and me.
- I always live up to the agreements with my supervisor.

The items used for this scale had to be answered using a 7-point Likert scale (Cronbach's alpha = 0.78).

The shadow of the future was measured using a variable indicating the level of contractual job security of the employee. This variable can obtain three values: when the employee had tenure, a value of three is assigned, when the contract is a temporary contract, with the promise of a tenure, we assigned the value two, and for temporary workers the variable took the value one.[4]

Risk aversion was measured in two ways: by a lottery question and by items expressing how much value an employee attaches to keeping her job. Following Hartog, Ferrer-i-Carbonell and Jonker (2000), respondents were asked what amount of money they are willing to pay for participation in a specified lottery, i.e. a lottery with a 0.1 probability of winning a prize of 5000 euros. The reservation prize in this particular lottery was 500 euros. Respondents who were willing to pay that amount are risk neutral. Respondents who answered they were willing to pay more are risk seeking, and respondents willing to pay less are risk averse. We assume risk attitude to be a scale, therefore the answers were computed into a *z*-scale and the scale was reversed. This means that a higher value indicates more risk aversion. Ideally, we would have used a construct using four more of these lottery questions. However, due to item non-response this was not possible.

However, risk aversion is not only a personality trait, as employees may have different degrees of risk aversion depending on their particular situation. Therefore, we used a second measurement of risk aversion, i.e. perceived job security, which captures aspects of an employee's work situation that affect risk aversion. To construct the scale for job security we used the following statements:

1. I am afraid of what might happen when I quit my job without having another job lined up.
2. If I quit, it will be hard to find a new job.
3. If I quit, too much would change.
4. How important is the following to you: to be certain I can work here for as long as I want.

The first, second and third items are derived from Allen and Meyer's (1990) concept of 'continuance commitment'. We used the items that expressed in some sense that the employee prefers this job to the uncertainty of no job. We did not use the items that referred to having to work as a necessity or to working for the organization because it provides better earnings than elsewhere. By using these items, we created a proxy for risk aversion. The fourth item was constructed by the researchers of the present study. The items used for this scale had to be answered using a 7-point Likert scale (Cronbach's alpha = 0.66). The higher the score on this scale, the larger the degree of risk aversion, i.e. the more the employee prefers the certainty of the current job to the uncertainty of a new job which may be either better or worse than the current one. This may hold even when the expected income and their liking of the new job is the same or – to a certain extent – greater. It should be noted that this scale does not take into account the extent to which the perception of job security reflects objective risks (e.g. having a low level of education, which makes finding a new job more difficult) or other individual characteristics of the respondents. However, in our theoretical analysis the risk aversion of employees reflects both their perception of the objective risks they are facing and their personal attitudes towards taking risks.

3.3 Analysis

Because the respondents are clustered in organizations, the data have a hierarchical structure. Therefore, it may be expected that the answers will not only be affected by the items, but also by organization-related characteristics. We therefore decided to use OLS regression, including dummy variables to control for unobserved variance caused by organization differences.

4 Results

4.1 Descriptive analyses

In Tables 1 and 2 the means, standard deviations and correlations of the variables used in the explanatory analyses are displayed for the subsample where risk aversion was measured with the lottery question and the job security question, respectively. In this first subsample, the dependent variable, 'cooperation with the supervisor', has a mean of 5.6 (s.d.=1.1), which is twice the standard deviation above the mid-score of the scale. This rather high value may result from the fact that it is a self-report on cooperation.

As for correlations with the dependent variable, we see that people with more education cooperate less with their supervisor (–0.22, $p<0.01$). Concerning the correlations with risk aversion in Table 1, significant correlations are found with female (0.22, $p<0.01$), indicating that women are more risk averse, and with schooling (–0.33, $p<0.01$), meaning that higher educated people are less risk averse. Also, the organization dummy yields a significant correlation (0.21, $p<0.05$). This means that, on average, the employees in the printing company are more risk averse than in the university.

Table 1. Correlations and descriptive statistics, for sample lottery question (N = 109)

	Mean	*s.d.*	*1*	*2*	*3*	*4*	*5*	*6*
1. Cooperation with supervisor	5.63	1.05						
2. Age	44.01	10.51	0.04					
3. Female	0.32	0.47	–0.02	–0.24**				
4. Schooling, years	13.43	3.61	–0.22*	–0.17*	0.14†			
5. Dummy printing company	0.51	0.50	0.12	0.04	–0.35**	–0.75**		
6. Risk aversion	0.08	0.14	–0.05	0.15†	–0.22*	0.33**	–0.21*	
7. Contract security	2.64	0.73	0.02	0.57**	–0.15†	–0.21*	0.08	0.10

Notes. ** = p<0.01, * = p<0.05, † = p<0.1; s.d. = standard deviation.

Table 2. Correlations and descriptive statistics for sample job-security question (N = 213)

	Mean	*s.d.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1. Cooperation with supervisor	5.68	1.05							
2. Age	43.83	9.51	0.04						
3. Female	0.32	0.47	0.04	–0.15*					
4. Schooling, years	12.88	3.37	–0.21**	–0.11†	0.12*				
5. Dummy care org.	0.43	0.50	0.08	–0.08	0.03	–0.22**			
6. Dummy printing comp.	0.30	0.46	0.06	0.08	–0.22*	–0.39**	–0.56**		
7. Risk aversion	4.53	1.59	0.14*	0.27**	–0.09†	–0.29**	–0.10†	0.28**	
8. Contract security	2.78	0.59	0.06	0.41**	–0.07	–0.19**	0.24**	–0.06	0.20**

Note. ** = p<0.01, * = p<0.05, † = p<0.1; s.d. = standard deviation.

In Table 2, mean and standard deviation of the dependent variables are very similar to those we found in the first subsample. Schooling is also negatively correlated with cooperation (–0.21, p<0.01). In this table we find a positive correlation of cooperation and risk aversion (0.14, p<0.05). We also see that risk aversion is positively correlated with age (0.27, p<0.01) and the two organization dummies (0.28, p<0.01 and

0.20, $p<0.01$ respectively). This means that here the university employees are more risk averse. Risk aversion is negatively correlated with schooling (–0.29, $p<0.01$) indicating that higher educated people are less risk averse.

4.2 Explanatory analyses

Table 3 shows the results of the regression analysis explaining employee cooperation with the supervisor, using the sample where risk aversion was measured by job-security. Table 4 shows the analyses with risk aversion measured by the lottery question.

There is no support for hypothesis 1. The contract security measure does not affect cooperation of employees in any of the analyses in Tables 3 and 4.

Hypothesis 2 was split into two constituents: the reward hypothesis (hypothesis 2a) and the relation hypothesis (hypothesis 2b). The first holds that employees will cooperate less the more risk averse they are, and the second holds that employees will cooperate more the more risk averse they are. The different measures of risk aversion show different results for this hypothesis. In Table 4, using the lottery question, we find no support for either hypothesis because the corresponding effect is not significant ($B = 0.81$, $p>0.1$). In Table 3, using the job-security questions, we find a significant effect for this variable when the interaction variables with the organization dummies are added. This indicates that risk aversion matters, but that it works differently in different organizations. We see that the interaction variable of risk aversion and care organization significantly differs from zero and is negative ($B = -0.31$, $p<0.01$). This shows that in the care organization risk aversion matters less than in the university department. When also looking at the magnitude and direction of the coefficients, we see that risk aversion is associated with cooperative behaviors in the university, but that the net effect is close to zero for the care organization and the printing organization. The hypothesis that is supported by the data is 2b (relation argument), but only for employees that work for the university.

Hypothesis 3 also consisted of two competing hypotheses: following the reward argument, hypothesis 3a holds that the more risk averse employees are, the smaller the positive effect of the shadow of the future on cooperation. Hypothesis 3b was derived from the relation view and holds that the more risk averse employees are, the larger the positive effect of the shadow of the future. In order to test these competing hypotheses, in both models interaction variables of risk aversion and

Table 3. OLS regression analysis explaining employee cooperation with the supervisor, risk aversion as job security

	B (*s.e.*)	*B* (*s.e.*)	*B* (*s.e.*)	*Hypothesis* (*direction*)
Age	0.00	0.00	0.00	
	(0.01)	(0.01)	(0.01)	
Female	0.16	0.20	0.20	
	(0.16)	(0.16)	(0.16)	
Schooling, years	–0.05†	–0.06*	–0.06*	
	(0.03)	(0.03)	(0.03)	
Dummy care org	0.11	0.00	–0.01	
	(0.22)	(0.22)	(0.22)	
Dummy printing org.	0.03	–0.04	–0.08	
	(0.25)	(0.25)	(0.26)	
University (ref.)				
Risk aversion	0.06	0.30**	0.28**	
(job security)	(0.05)	(0.09)	(0.10)	2a (–), 2b (+)
Contract security	0.01	–0.05	–0.09	
	(0.14)	(0.16)	(0.17)	1 (+)
Risk aversion * care org.		–0.32**	–0.31**	
		(0.11)	(0.12)	
Risk aversion * print org.		–0.29*	–0.27†	
		(0.14)	(0.14)	
Risk aversion* contract security		0.00	–0.06	
		(0.09)	(0.12)	3a (–), 3b (+)
Risk aversion* care* contract			0.07	
			(0.18)	
Risk aversion* print* contract			0.16	
			(0.20)	
Constant	6.25**	6.38**	6.37**	
Adjusted R^2	0.03	0.05	0.05	

Note. ** = $p< 0.01$, * = $p< 0.05$, † = $p< 0.1$; s.e. = standard error, org. = organization; ref. = reference category.

contract security were added. In the models in Tables 3 and 4 we find no support for either hypothesis.

With respect to the control variables, Table 3 shows that employee cooperation with the employer does not differ with age and gender. We also see that more education is negatively associated with employee cooperation.

Table 4. OLS regression analysis explaining employee cooperation with the supervisor, risk aversion as lottery question

	B (*s.e.*)	*B* (*s.e.*)	*B* (*s.e.*)	*Hypothesis* (*direction*)
Age	0.00	–0.00	0.00	
	(0.01)	(0.01)	(0.01)	
Female	–0.03	–0.07	–0.08	
	(0.25)	(0.26)	(0.26)	
Schooling, years	-0.10^{*}	–0.08†	–0.08†	
	(0.05)	(0.05)	(0.05)	
Dummy printing org.	–0.26	–0.20	–0.22	
	(0.34)	(0.34)	(0.36)	
University department (ref.)				
Risk aversion	0.25	–0.78	–0.81	2a (–), 2b (+)
	(0.82)	(1.02)	(1.03)	
Contract security	–0.08	–0.08	–0.06	
	(0.17)	(0.17)	(0.19)	1 (+)
Risk aversion* printing company		2.71†	2.58	
		(1.62)	(1.73)	
Risk aversion* contract security		–1.35	–1.43	3a (–), 3b (+)
		(1.23)	(1.27)	
Risk aversion* printing company* contract			–1.03	
			(4.39)	
Constant	6.94^{**}	7.00^{**}	7.04^{**}	
Adjusted R^2	0.00	0.01	0.06	

Note. ** = $p< 0.01$, * = $p< 0.05$, † = $p< 0.1$; s.e. = standard error, org. = organization; ref. = reference category.

In order to test whether the interaction between the shadow of the future (job security) and risk aversion varied between organizations, we included three-way interactions in both models, combining the interaction effect predicted by hypotheses 3 with the dummy variables controlling for organization differences. Here, we find no significant coefficients.

5. Conclusions and discussion

In this paper, we investigated whether and how risk aversion affects employee cooperation with the employer in long-term labor relations.

The mutual-investment model emphasizes that a shadow of the future supports cooperation in ongoing exchanges between employer and employee. However, it remains unclear which, in this view, are the expected effects of risk aversion and how these interact with the shadow of the future. We distinguished, formalized, and tested two conflicting arguments in the literature, both of which turn out to be consistent with the view that a longer shadow of the future increases cooperation. We showed that according to the relation model, risk aversion should influence employee cooperation positively, and that there should be a positive interaction between risk aversion and the shadow of the future on employee cooperation. We also derived that according to the reward argument, more risk-averse employees should cooperate less, and that the larger the risk aversion the smaller the effect of the shadow of the future.

In the empirical analysis, the theoretical expectations were only partially confirmed. We found support for hypothesis 2b, which predicts that risk aversion favors cooperation. However, this result is only found for employees of the university organization, in the case of risk aversion being measured in terms of job security.

As for the theoretical implications, the effects we found do not provide strong support to either of the two models, but overall they were somewhat more in line with the relation argument. This would suggest that the more risk averse people are, the more they cooperate with the employer. However, our results do not support the expectation that features of the incentive structure that increase the shadow of the future, such as long-term contracts, have a direct effect on employee cooperation, or that they have an indirect effect by strengthening effects of risk aversion. The results of our analysis also do not suggest that the mutual investment model of the labor relationship would gain considerably in predictive power if the individual level characteristic of risk aversion is taken into account. We find different outcomes for the effect of risk aversion on cooperation for different types of organizations. We only find support for the notion that risk aversion favors cooperation in the university organization. Differences in the organizational (incentive) structure may be responsible for these differences. Surprisingly, however, the incentive structure of a university typically resembles more the assumptions of the reward model, which predicts a negative effect of risk aversion on cooperation, which is the opposite of what we actually found for the university. In the university, the incentives based on career enhancement are likely to be less frequent, but the rewards are also larger (more similar to one-shot rewards). In the other organizations, incentives are more likely to be given in the form of more frequent, smaller rewards (pay raises, more responsibility, a position with more influence). The reward model portrays the one-shot situation similar to the typical career incentives of a university, but it predicts that risk aversion should negatively affect employee cooperation.

Perhaps this can be explained by differences in the clarity of the boundary of the position. In a printing company or a care organization, the tasks that belong to a particular position are typically more clearly defined than the tasks of a university professor. It is therefore less clear at the university which task should be performed by someone else. This might have the consequence that the employees at a university are more likely to take on extra tasks when asked than employees in another organization.

Our paper may also generate some insight into the empirical measurement of risk aversion. We did not find any support for risk aversion on cooperation when we used the lottery question. Several reasons may have caused this. The first reason may be that we were not able to construct the scale out of multiple items, but could only use one item. This could have corrupted the measurement. The second possible reason is that risk aversion may depend on the interpretation of the situation for which respondents evaluate the relative attractiveness of different outcomes. Obviously, an abstract lottery with monetary outcomes is a situation that is very different from a work environment. This difference may also affect the degree of risk aversion when it comes to making actual choices for one of the two situations. Therefore, risk attitude in a lottery may be uncorrelated with risk aversion with respect to decisions made at work, such as investments in cooperation. This would mean that for every situation, different measurements of risk aversion would have to be constructed, based on the situation in which the data is gathered, in order to test hypotheses concerning risk aversion.

In this paper, we tried to disentangle two lines of reasoning about effects of risk aversion on employee cooperation. The two arguments we inspected are based on very similar assumptions. However, it turned out that small differences in the assumptions entail opposing expectations on the effect of risk aversion on employee cooperation. The moderate support that we found in our empirical study suggests that more research is needed to understand the effects of risk aversion on employee cooperation. We believe that future work should focus in particular on how the organization specific properties of the incentive structure influence effects of risk aversion, and on the appropriate measurement of risk attitudes related to workplace decisions.

Appendix

Derivation of equation (3)

The expected number of rounds of the total game is $\sum_{0}^{\infty}\alpha^{t}=\frac{1}{1-\alpha}$, and the expected number of rounds after time point t^{*} is $\sum_{t^{*}+1}^{\infty}\alpha^{t}=\frac{\alpha^{(t^{*}+1)}}{1-\alpha}$. Subtracting the second expression from the first expression yields the expected number of rounds until the reward time t^{*}, $\frac{1-\alpha^{(t^{*}+1)}}{1-\alpha}$.

Derivation of condition (4)

To be shown: $u_C > u_D$ is equivalent to $\frac{\alpha^{t^{*}}}{l_c}>\frac{U(0)-U(-c)}{U(R^{*})-U(0)}$. As a first step, we derive from equations (1) and (2) the expected utility of cooperation, which yields $u_C = \alpha^{t^{*}}U(R^{*})+l_cU(-c)$. The condition for cooperation is that the resulting term exceeds $u_D = \alpha^{t^{*}}U(0)+l_cU(0)$, which is equivalent to $u_C > u_D$. It becomes apparent after some rearrangement that this condition is equivalent to $\alpha^{t^{*}}(U(R^{*})-U(0))>l_c(U(0)-U(-c))$. Multiplication of both sides of the inequality with $(l_c(U(R^{*})-U(0)))^{-1}$ yields $\frac{\alpha^{t^{*}}}{l_c}>\frac{U(0)-U(-c)}{U(R^{*})-U(0)}$, due to $((U(R^{*})-U(0)>0$ and $l_c>0$. This result is equivalent to condition (4).

Derivation of hypothesis 1 for delayed reward game

Hypothesis 1 follows from the analysis of the partial derivative of the attractiveness of cooperation, a_C, by α. We defined $a_C=\frac{\alpha^{t^{*}}}{l_c}-\frac{U(0)-U(-c)}{U(R^{*})-U(0)}$ (see above). Hypothesis 1 states that the partial derivative of a_C by α is positive, i.e. $\frac{\partial a_C}{\partial\alpha}>0$. The partial derivative is, after some simplification, obtained as $\frac{\partial a_C}{\partial\alpha}=\frac{\alpha^{(t^{*}-1)}(\alpha^{t^{*}+1}+t^{*}-\alpha(t^{*}+1))}{(\alpha^{t^{*}+1}-1)^{2}}$. This expression is negative iff the numerator is negative, because the denominator is always larger than zero (excluding the degenerate case $\alpha = 1$). The condition for a negative numerator is equivalent to $\alpha^{t^{*}+1}+t^{*}-a(t^{*}+1)< 0$. This can never be true for the following reasons. First, at $\alpha = 0$, the l.h.s. term of this inequality yields t^{*}, which is positive. Second, at $\alpha = 1$, the l.h.s. term yields 0. Given this, if the l.h.s. term would be negative anywhere in between $\alpha = 0$ and $\alpha = 1$, then its first-order derivative in a must be positive at some point in this interval (because otherwise it could not reach from a negative value its value at $\alpha = 1$, which is 0). However, this cannot be the case, because the first-order derivative of the l.h.s. subterm evaluates to $\alpha^{t^*}(t^*+1)-(t^*+1)$, which is guaranteed to be negative given the preconditions $0 < \alpha < 1$ and $t^*>1$. This proves that the attractiveness for cooperation increases in a. This implies hypothesis 1 if we assume that there is at least a positive probability that a_C is larger than zero above some point in the interval in which a varies.

Derivation of effect of t^* on restrictiveness of condition (4)

To show that the restrictiveness of condition (4) increases in t^*, we need to prove that $\frac{\partial a_C}{\partial t^*} < 0$. We obtain $\frac{\partial a_C}{\partial t^*} = \frac{(1-\alpha)(\alpha^{t^*}\mathrm{Log}(\alpha))}{(\alpha^{t^*+1}-1)^2}$. This expression is negative iff its denominator is negative. The denominator is negative, because $(1-\alpha)>0$, $\alpha^{t^*}>0$ and $\mathrm{Log}(\alpha)<0$ due to $0<\alpha<1$.

Derivation of hypothesis 2 for the delayed reward game

To be shown: the higher the risk aversion of utility function U, the lower is the attractiveness of cooperation in the delayed reward game, all other things being equal. Definition 1 implies, if risk aversion of utility function U is higher than risk aversion of utility function V, then $U(0) > V(0)$ and $U(-c) = V(-c)$ and $U(R^*) = V(R^*)$. Hence, if the attractiveness of cooperation decreases strictly in $U(0)$, that is, if $\frac{\partial a_C}{\partial U(0)} < 0$, then the attractiveness of cooperation also decreases in risk aversion of the utility function. In the following, we show that $\frac{\partial a_C}{\partial U(0)} < 0$. The first order partial derivative of a_C by $U(0)$ is obtained as $\frac{\partial a_C}{\partial U(0)} = \frac{U(-c)-U(R^*)}{(U(0)-U(R^*))^2}$. This expression is always negative, because the numerator is always positive and the denominator negative due to $U(-c) < U(R^*)$. This shows that $\frac{\partial a_C}{\partial U(0)} < 0$, which proves that the higher the risk aversion of utility function U, the lower is the attractiveness of cooperation in the delayed reward game. This implies hypothesis 2a if we assume that there is at least a positive probability that a_C is larger than zero above some point in the interval in which $U(0)$ varies.

Derivation of the limiting values of attractiveness of cooperation in delayed reward game

a) Limiting value of a_C for $\alpha \rightarrow 0$.

We show that $a_c = \frac{\alpha^{t^*}}{l_c} - \frac{U(0) - U(-c)}{U(R^*) - U(0)}$ is always negative at $\alpha = 0$.

The sub term $\frac{\alpha^{t^*}}{l_c} = \frac{\alpha^{t^*}(1-\alpha)}{1-\alpha^{(t^*+1)}}$ evaluates to 0 if $\alpha = 0$. This is also the limiting value of a_C for $\alpha \rightarrow 0$, because the limit for the numerator is positive and well defined, and the limit for the denominator is zero.

b) Limiting value of a_C for $\alpha \rightarrow 1$.

The second sub term of a_C, $-\frac{U(0) - U(-c)}{U(R^*) - U(0)}$, is constant in α. Hence, the limiting value of a_C for $\alpha \rightarrow 1$ is the difference between the limiting value of the first sub term, $\lim_{\alpha \to 1} \frac{\alpha^{t^*}}{l_c} = \lim_{\alpha \to 1} \frac{\alpha^{t^*}(1-\alpha)}{1-\alpha^{(t^*+1)}}$, and the second sub term. The limiting value $\lim_{\alpha \to 1} \frac{\alpha^{t^*}(1-\alpha)}{1-\alpha^{(t^*+1)}}$ can be obtained by application of the rule of de l'Hôpital. To apply de l'Hôpital's rule, we need to obtain the quotient of the partial derivatives in α of the numerator and of the denominator of this expression. After some simplification, this yields:

$$\frac{\frac{\partial(\alpha^{t^*}(1-\alpha))}{\partial\alpha}}{\frac{\partial(1-\alpha^{(t^*+1)})}{\partial\alpha}} = \frac{\alpha - t^* + \alpha\, t^*}{\alpha + \alpha\, t^*} \tag{A1}$$

Applying de l'Hôpital's rule we obtain from (A1) the limit for $\alpha \rightarrow 1$ from the limit of the r.h.s. of (A1) for $\alpha \rightarrow 1$. This limit evaluates straightforwardly to $(1 + t^*)^{-1}$, because this is the well-defined value of the function given by the r.h.s. of (A1) and thus also the limit of $\frac{\alpha^{t^*}}{l_c}$ for $\alpha \rightarrow 1$. This implies that the limit value of the attractiveness of cooperation if a approaches 1 is $\frac{1}{(t^*+1)} - \frac{U(0) - U(-c)}{U(R^*) - U(0)}$.

NOTES

1. Following Knight (1921) authors sometimes distinguish between risk and uncertainty. Risk refers to a situation in which the probabilities of the possible outcomes are known to the actors in advance (e.g. in the case of a lottery), and uncertainty refers to a situation in which the probability of the outcomes are unknown to the actors (see e.g. Pindyck and Rubinfeld 2005). However, Ellsberg (1961) shows that people are

similarly uncertainty averse as they are risk averse. Additionally, much sociological and economic literature uses the term risk in the case of uncertainty and so will we.

2. A utility function is concave if for any two payoffs x and y, the utility that is derived from the lottery $pU(x) + (1-p)U(y)$, falls below the utility of obtaining the expected payoff of this lottery for certain.
3. This interpretation reflects the assumption that we have not included all heterogeneity into our model. For example, suppose for a specific employee i, the values on the l.h.s. and the r.h.s. of inequality (4) are quasi-normally distributed random variables with mean values given by the corresponding terms. Then this implies that the higher the term on the l.h.s. and the smaller the term on the r.h.s., the higher is the likelihood that the inequality is satisfied and thus cooperation would be chosen by the employee.
4. This operationalization might be criticized for being inconsistent with the theoretical notion of an indefinite game that we use to formalize the continued reciprocity argument, because with a non-tenured contract the game is obviously not indefinite. However, even with a non-tenured contract there is usually some probability of continuation of the labor relationship, because often employers signal that there is a prospect of permanent employment in case of satisfactory performance on the part of the employee.

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MATTIJS LAMBOOIJ is a researcher for the National Institute for Public Health and the Environment. Lambooij took his PhD in 2005 at the University of Utrecht, in the Interuniversity Center for Social Science Theory and Methodology (ICS). He has published in the *Internal Journal of Human Resource Management*. His research interests are cooperation of employees in labor organizations, effectiveness of healthcare systems, and labor and health.

ADDRESS: The National Institute for Public Health and the Environment (RIVM), P.O. Box 1, 3720 BA, Bilthoven, The Netherlands [email: mattijs.lambooij@rivm.nl]

ANDREAS FLACHE is Professor of Sociology, with particular emphasis on modeling norms and networks, at the Department of Sociology, Faculty of Behavioral and Social Sciences, University of Groningen. He is a staff member of the Interuniversity Center for Social Science Theory and Methodology (ICS). His research addresses cooperation problems and social integration, social networks and learning theory, using computational and game theoretical modeling, laboratory experimentation, and survey research. He has been published in the *Journal of Conflict Resolution*, *Rationality and Society*, *Journal of Mathematical Sociology*, and *Proceedings of the National Academy of Sciences*.

ADDRESS: Department of Sociology/ICS, Faculty of Behavioral and Social Sciences, University of Groningen, Grote Rozenstraat 31, 9712 TG, Groningen, The Netherlands [email: a.flache@rug.nl]

JACQUES SIEGERS is Professor of Economics at Utrecht University. He is a staff member of the Interuniversity Center for Social Science Theory and Methodology (ICS). From 1991 to 2003, he was a member of the Board of the ICS. From 1988 to 2002, he was coordinator of the Centre for Interdisciplinary Research on Labor Market and Distribution Issues (CIAV), Utrecht University. In the period 1986–1994, he was part-time detached at the Netherlands Interdisciplinary Demographic Institute (NIDI), The Hague. His main area of research is applied microeconomics.

ADDRESS: Department of Economics, Utrecht University, USE – Utrecht University, Vredenburg 138, 3511 BG, Utrecht, The Netherlands [email: j.j.siegers@econ.uu.nl]